The National Center for Hydrologic Synthesis at Berkeley (NCHS)

Our Plan Today:

- The Challenges of modern hydrology
- The NCHS concept
- Present a road map for hydrologic synthesis;
- Partners
- Performance metrics
- Seeds of Hydrologic Synthesis

- Hydrology is an earth science which encompasses the occurrence, distribution and properties of the water of the earth and their environmental relations. Closely allied fields include geology, climatology, meteorology and oceanography..and more..

- Hydrology was driven until recently primarily by the narrowly focused issues of engineering hydrology.

- It is now clearly documented that the 20th Century hydrology paradigm is inadequate in face of the increase in number, severity, complexity and the scale of the water-related science questions facing the world.

Examples for the Challenges to Modern Hydrology:

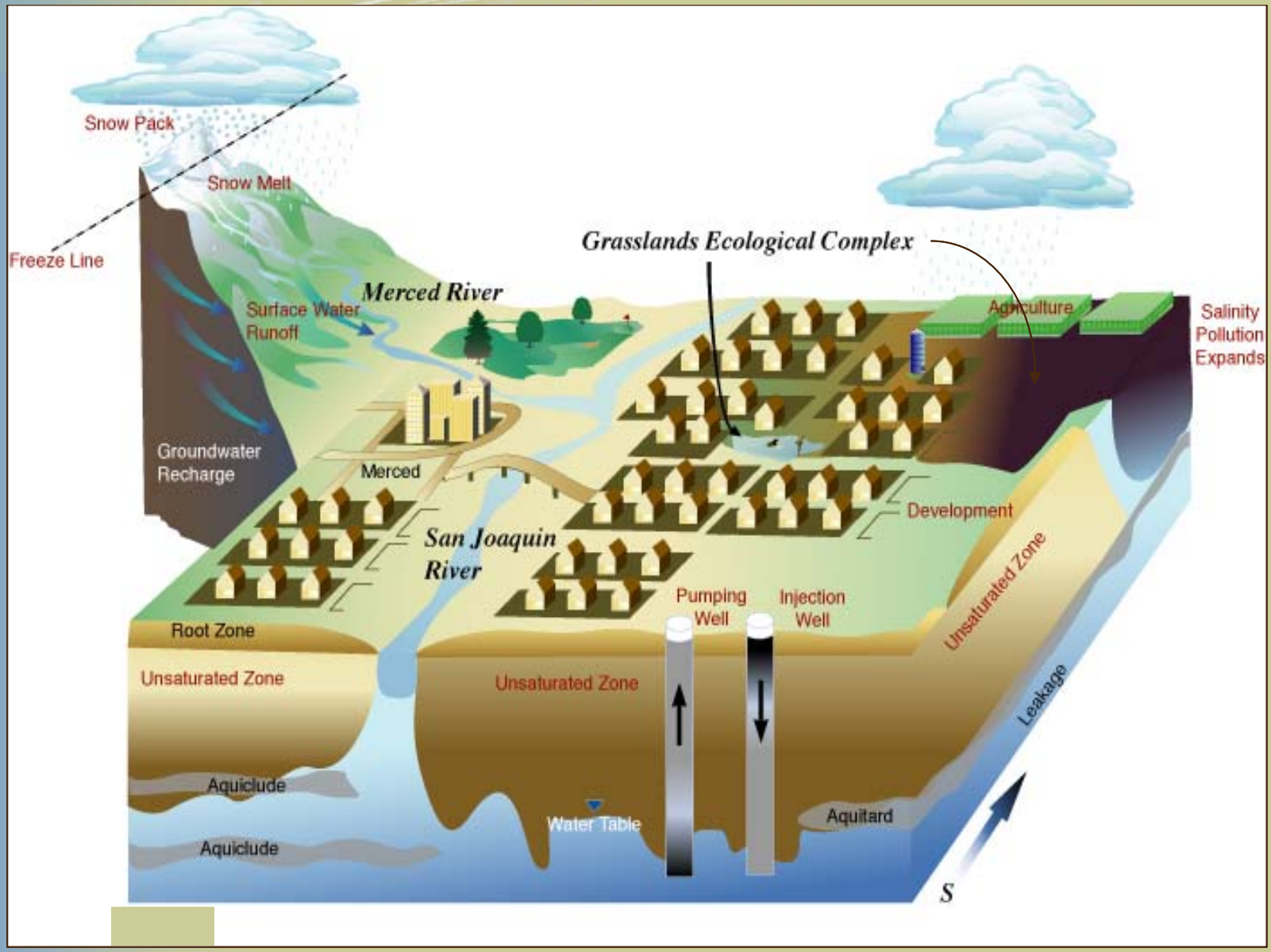
(1) Can we use elements of fluid dynamics, atmospheric and hydrologic sciences to develop a theory that will predict the initiation, duration and termination of hydrologic droughts?

(2) Can we combine elements of economy and behavioral sciences together with oceanography and atmospheric science to predict the anthropogenic effects of a carbon-emissions constrained world on the hydrologic cycle?

(3) What are the consequences of global warming on hydrology, and what are the environmental and ecological consequences?

(4) How do we use the modern tools of information technology and wireless communications to improve field data acquisition, storage, and retrieval?

(5) What are the spatial and temporal relationship among biota, hydrology and geomorphology across scales, from microhabitats to channel units to valleys to large catchments?


Snow Pack
Snow Melt
Freeze Line
Grasslands Ecological Complex
Merced River
Surface Water Runoff
Agriculture
Salinity Pollution Expands
Groundwater Recharge
Merced
Development
San Joaquin River
Pumping Well
Injection Well
Root Zone
Unsaturated Zone
Unsaturated Zone
Unsaturated Zone
Leakage
Aquiclude
Water Table
Aquitard
Aquiclude
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The Idea:

- CUAHSI identified the need for a Synthesis Center that will:

  1. Promote the creation of a vision for the future of hydrologic science;

  2. Cultivate an interdisciplinary research culture;

  3. Offer new opportunities for cross-disciplinary research;

- To implement it, we needed to define the **drivers** of the new hydrology paradigm;
- **From drivers to plan characteristics to programmatic elements**;

Drivers of the Modern Hydrology Paradigm

1. Emergence of continental and global-scale problems.

2. Interconnectedness of nature and the changes caused by humans.

3. The need to balance between Economy, Ecosystems, Equity.

Where does that leave us?

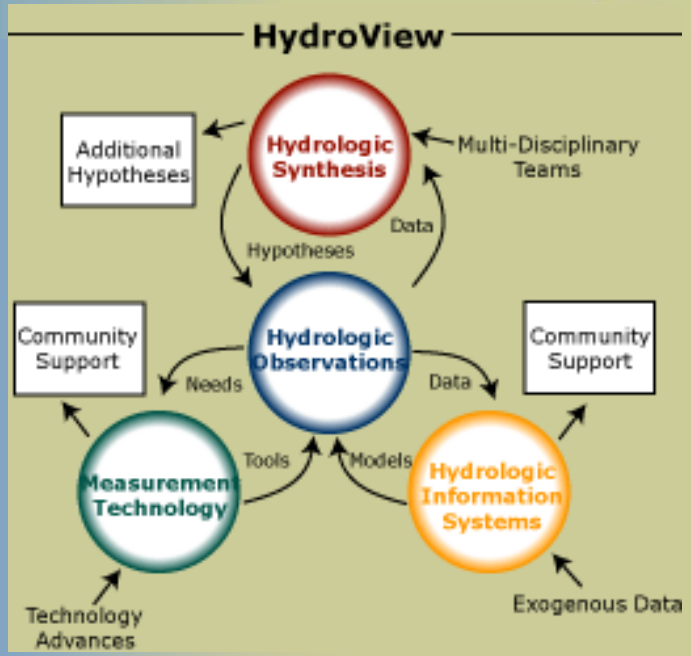
- Dealing with systems that range from the “understandable” and “predictable” (floods, hurricane landfalls) to the “non-understandable” and “unpredictable” (nuclear waste repositories, long term behavior of ecosystems, climate),
- complex, non-linear, coupled systems,
- ..and doing all that with little or no data..
- …but with new research challenges, as determined by the drivers of the modern hydrology paradigm..

New Aspects of Research in Hydrology:

- Research is needed to understand human behavior under ecological, physical and institutional constraints
- Research must include multiple stakeholders from a variety of science disciplines as well as the government, public and the private sectors;
- Research is needed to develop the technology for acquiring and analyzing data at unprecedented scales;

To meet these Challenges, the NCHS model must include the following:

- **Access to data** – develop and test new theories and models; through long-term observatories, existing data bases accessible through national and international affiliations;
- **Interdisciplinarity** –Interdisciplinary research teams, with participation from the earth, life, atmospheric/climate, and social sciences and from engineering;
- **Collaboration and partnerships –**hydrologists will need to form unconventional and nontraditional research coalitions, with environmental leaders, policy experts, public and private sectors hydrology stakeholders and end users;
- **Knowledge discovery platform** – including advanced computing and visualization; sensors, wireless and IT expertise, open grid computing and interoperability;



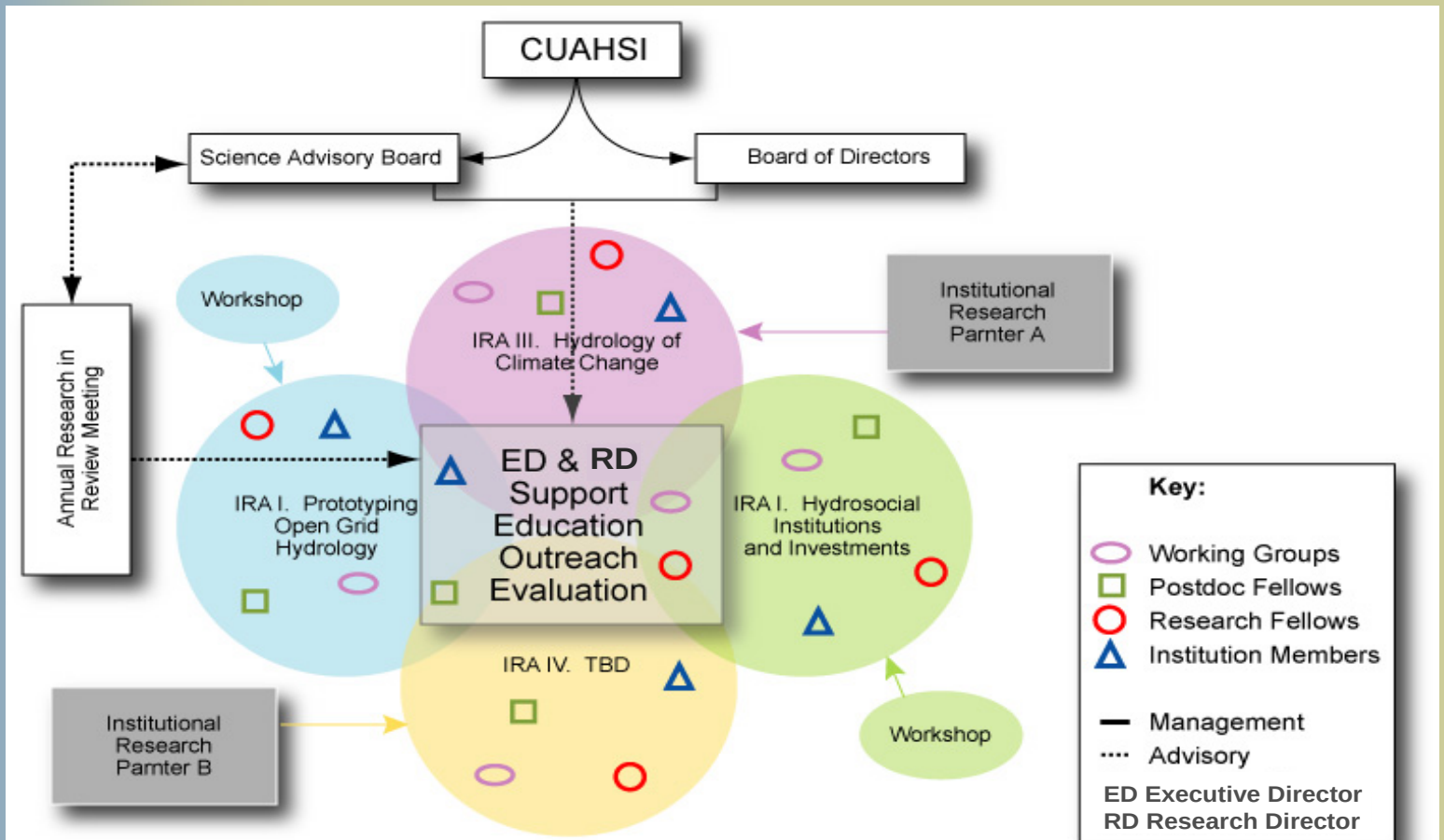
Hydrologic Observatories: A set of Long Term Observatories at which data will be acquired to Support research on pressing Hydrologic problems. Selection criteria include diversity of hydrologic setting, climate, geography, built environment..

Hydrologic Information Systems: provide hydrologic scientists with user-friendly access to the data generated by the observatories as well as user-friendly interfaces with the complementary data sets generated by other organizations; A repository of computer routines that can facilitate visualization and analysis of the data

Measurement Technology: provide a clearinghouse for instrumentation to support data collection at the Long-Term Hydrologic Observatories, to support research projects both at and away from the observatories, and will provide the university research community with advice on the proper use and maintenance of the instrumentation.

- NCHS will lead the effort in creating an effective bridge among the HydroView components, and in maximizing HydroView's benefits for the science community;
- The guiding principle is that HO, HIS and HMT are focused on acquiring data and creating technologies, while NCHS's role is to bring together the people that will generate knowledge and ideas to make sense from all this information and technology.
- NCHS activities will include developing hypotheses that will guide data acquisition, and that will stimulate inter-comparison and scaling analyses. It will create a rational approach for acquiring data bases that are **coherent** (i.e., data that "fit together" in time and space, to describe hydrologic processes), **multi-scale** (i.e., data must link between processes at the small catchment scale, at the river basin scale and the continental scale), **multi-disciplinary** (since it is a combination of physical, chemical and biological and engineered processes that control hydrologic phenomena), cover a **wide range of settings**, representing a **wide range of climates, landforms and geological settings**, where different processes may dominate, and that sample the dominant processes.
- This will allow development and testing of theories on hydrological processes across widely-diverse settings.

A Road Map for Synthesis



Note: The Integrated Research Areas (IRAs) listed here are preliminary, and the distribution of personnel within the IRAs is schematic.

Principles of Synthesis:

- Broad **intellectual** support system (reach out to new sectors, new disciplines)
- Clear **articulation** of the **center's vision** and of the **science and technical barriers**
- **Diversity** of research modes;
- Cross-disciplinary unifying themes;
- Orientation
- Research platform that is **rich in resources;**
- Learning curve – **metrics**

An example for a unifying theme: Hydrology of Extreme events

- From a scientific point of view, extreme events are a potent unifying theme: researchers in diverse fields are applying similar tools (e.g., statistics, mathematical models, complexity theory) to the study of a great variety of extreme events;
- These various tools also share the need for similar technologies and techniques (observations, data assimilation, supercomputing, visualization);
- More challengingly: extreme events reflect interactions between different types of systems, understanding them is intrinsically an interdisciplinary goal;
- For example, research on algal blooms require knowledge of local ecology of algae, biogeochemical cycles that control nutrient production, the hydrological character of the aqueous system, upstream irrigation, fertilization and farm policies, and local and regional climate conditions.

The IRA (Integrated Research Area)

- IRAs are the **main vehicle** for facilitating cross-disciplinary research;
- IRAs will represent arenas of inquiry in which **cross-cutting collaborations** are likely to produce significant progress, and reflect the needs and interests of the **hydrology community at large**,
- IRAs will be **selected, assessed and eventually terminated by the Center's Scientific Advisory Board** (SAB), based on their significance and potential for promoting the Center's vision and strategic plan, with input from CUAHSI and the hydrology community (workshops, annual mtgs);
- Provide broad outlines rather than narrow definitions for the Center's work;

More on IRAs:

- Will be established with **ancillary topics** and questions, intended to assist researchers orient their proposals and assist staff in mapping strategic synergies;
- **Three levels of research**: basic and applied, development of enabling technology and testing of concepts, and application tools;
- IRAs will cooperate closely with other components of **CUAHSI's HydroView;**
- Milestones;

..and finally..

- In addition to IRAs managed directly by the Center, Center's researchers will work closely with the Center's International Research Partners (IRPs): MoU signed with UFZ and VTT; Letters of Intent received from CWN and IWMI.
- Exceptional and promising opportunities outside of IRAs should be pursued;

Modes of Synthesis:

- **Working Groups**:

1. 5-15 members from different disciplines, institutions, and sectors;
2. Working on a specific, mutually-defined problem, project, product, pertinent to the hydrology community (usually) within the constraints of the IRA;
3. Selected through a competitive process, using criteria of intellectual merit, scientific relevance, organization fit, and innovation;
4. Can be also appointed by the Center's Boards, to pursue special opportunities or by request;

..more..

- **Continuity**:

1. WG will be encouraged to **collaborate with** and **provide guidance to** Center's researchers outside of the WG membership; Postdoctoral and doctoral students will be encouraged to establish close links with WG members;
2. **Limited time appointments** for Working Group Leaders;

Communicating with the Community:

- ***Workshops.*** The Center will host a series of regular science and policy workshops on topics related to the Center's on-going and proposed IRAs.
- ***Annual Research in Review Meeting.*** This will be an open "town hall" for stakeholders from the hydrology community to review current and future Center's activities. This meeting will be coordinated to coincide with the Fall Meeting of the American Geophysical Union, or will rotate between AGU and other society meetings, such as those associated with IAHS.

Postdoctoral and Doctoral Fellows:

- Selected annually on a competitive basis, based on guidelines developed with Boards
  - extensive advertising to secure broad participation;
- Criteria: Quality of proposal and proposer; compatibility of project with research directions of the Center (IRAs)
  - ability to benefit from the Center's collaborative research environment
- Encouraged to communicate and collaborate with WGs;
- Doctoral students: 1-year fellowship max, intends to augment funding from home institution
  - visit is intended to provide a collaborative research experience of both student and advisor; after advancement to candidacy;
- Postdocs: 2 year appointments with possibility of extension; full salary and benefits and a small research stipend;

..orientation..

- Participate in an **Orientation Workshop:** familiarize with affiliates, activities, projects and individuals; and
- A **semester course** covering the data, concepts, methods, instruments, applications, and contributions of the various disciplines contributing to the Center;

Visiting research Fellows:

- Fellowships will be awarded to researchers and professionals from academia, industry, government and public non-government;
- Goal is to enrich the Center's activity with diversity of opinions, experiences and perspectives;
- Equitable and rational funding model. In many cases funded by home institution/agency;
- Encouraged to work with Doctoral and Postdoctoral Fellows and with Working Groups.
- Participate in Orientation Workshop, if possible.

Communicating the Center's Work:

- **Graphic Artist-in-Residence and Science Writer-in-Residence**:
- **Goal**: Communicating the wealth of information that will be created at the Center efficiently and aesthetically
- Professionals to stay at the center for extended periods of time, interact with Center's researchers, participate in the Center's functions, and will contribute their expertise toward **improving the Center's ability to communicate its work**.

Role of Center's Leadership:

- Articulate the Center's vision both internally and externally;
- Custodian of the Hydrologic Synthesis vision;
- Provide a clear perception of the current status of the field and a vision of future advancements and a strategy to achieve them;
- Recognize intellectual needs and identify needed talents required to sustain a cross-disciplinary team over time.

NCHS Partnerships

Because ***multi-sectoral*** and ***multi-disciplinary*** input is critical to tackling large-scale synthesis in a holistic manner, the NCHS @Berkeley has partnered widely with various institutions

Our partnerships fall into **four categories**:

- **Institutional Members** have varying degrees of direct involvement with the center, and provide their perspective and experience to the center, as well as with some resources:
  - International Research Partners
  - Industrial Affiliates Program

- **Institutional Research Partners** are institutions whose missions are closely aligned with or complement NCHS, and who are strategically positioned to assist NCHS through leveraging of resources;

- **IT Partners** assist the NCHS with technical expertise, computational resources, and equipment;

- **Educational Partners** participate with NCHS in achieving its education and outreach mission.

Examples of Different Institutional Membership Elements

- **International Research Partners** (IRPs) will work closely with the NCHS researchers on joint IRAs to leverage the Center's resources and expand its scope of activities. Principles:
  - the ***joint IRA*** forms a basis for collaboration;
  - IRP to **co-manage** in-house activities
  - IRP will commit **resources** to support joint IRA at *both* the Center and the IRP location;
  - The IRPs will fund **education & outreach** activities with the NCHS;
- **Industrial Affiliates (IA) Program**
  - Membership Program **Prospectus**
  - Private industry annual contributions are expected to be in the range between $**65,000** to $**125,000** per year.
  - IA '**ramp up**' plan

IRP Institutional Member Example:

VTT – Finland's independent technology and research institution

Kaarlo Heiskanen, VTT

•**Technology Experts**: fields of IT, biotechnology, chemical engineering, energy, construction and communications;

•Annual **budget ~213 M€** (Tekes, public and private sector domestic, and international)

•VTT's R&D model is based on **collaborative efforts** between VTT scientists, universities, and private industries;

•**VTT wants to strengthen** its :

- •Connections to UCB and LBNL (and ultimately US universities) using NCHS as a cooperation platform;
- •Connections to new water and related subsurface technologies and new IT platforms to support them

Current **MOU** involves 19 VTT research groups and ~260 VTT researchers.

The financial aspects of MOU include: $1.2 m/year co-managed, $120k/year cash, $12k/year outreach, $12k/year meetings

Industrial Affiliate Institutional Member Example: Schlumberger

Dominic McCann

- Schlumberger Water Services specializes in providing groundwater assessment, development, and management services;

- Plethora of **tools** developed for petroleum reservoirs that could be useful for watershed and aquifer characterization and management;

- Interested in:
  - Parlaying their reservoir management **expertise** into **aquifer management**, but are **frustrated** by current fragmented nature of aquifer mgmt;
  - Exploring the NCHS as a platform for **better communication** between private sector, hydrology research community, and policymakers/agencies;
  - Working with CUASHI (HO researchers) on **instrumentation development**;

- Partner at **125k level**, using ramp-up plan

Schlumberger

NCHS @ Berkeley Partners

Institutional Members:

- UFZ-Umweltforschungszentrum Leipzig-Halle GmbH
- VTT
- Lawrence Berkeley National Laboratory
- Lawrence Livermore National Laboratory
- LFR Levine Fricke
- Malcolm Pirnie
- UC Berkeley
- U.S.G.S. National Research Program
- U.S.G.S. California Water Program
- Schlumberger
- Bechtel

Institutional Research Partners:

- CALFED
- CA Dept.Water Resources
- Canadian Water Network
- International Water Management Institute
- Pacific Institute
- SwissNex
- U.S. Bureau of Reclamation

Computational/IT Partners:

- National Energy Research Computing Center (NERSC)
- San Diego Super Computer
- Center for Information Technology Research in the Interest of Society
- GlobeXplorer
- HP
- IBM Almaden
- NASA Ames Research Center
- Microsoft
- Hydrologic Information Systems (HIS)

Education and Outreach Partners:

- Environmental Science Teaching Program
- Exploratorium of San Francisco
- Lawrence Hall of Science
- UC Merced/SNRI
- Water Resources Center Archive

NCHS Partnerships are:

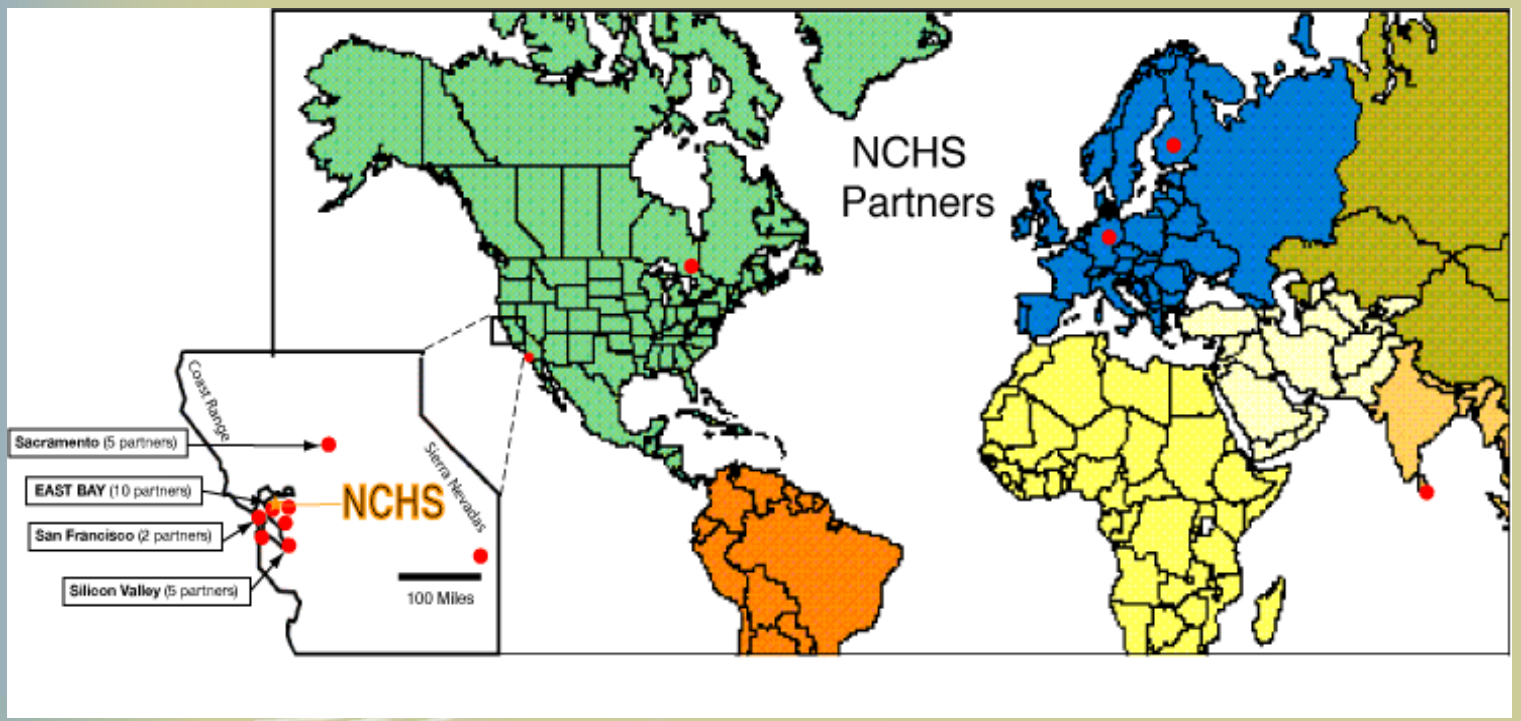
Multi-Sectoral, Multi-disciplinary

International

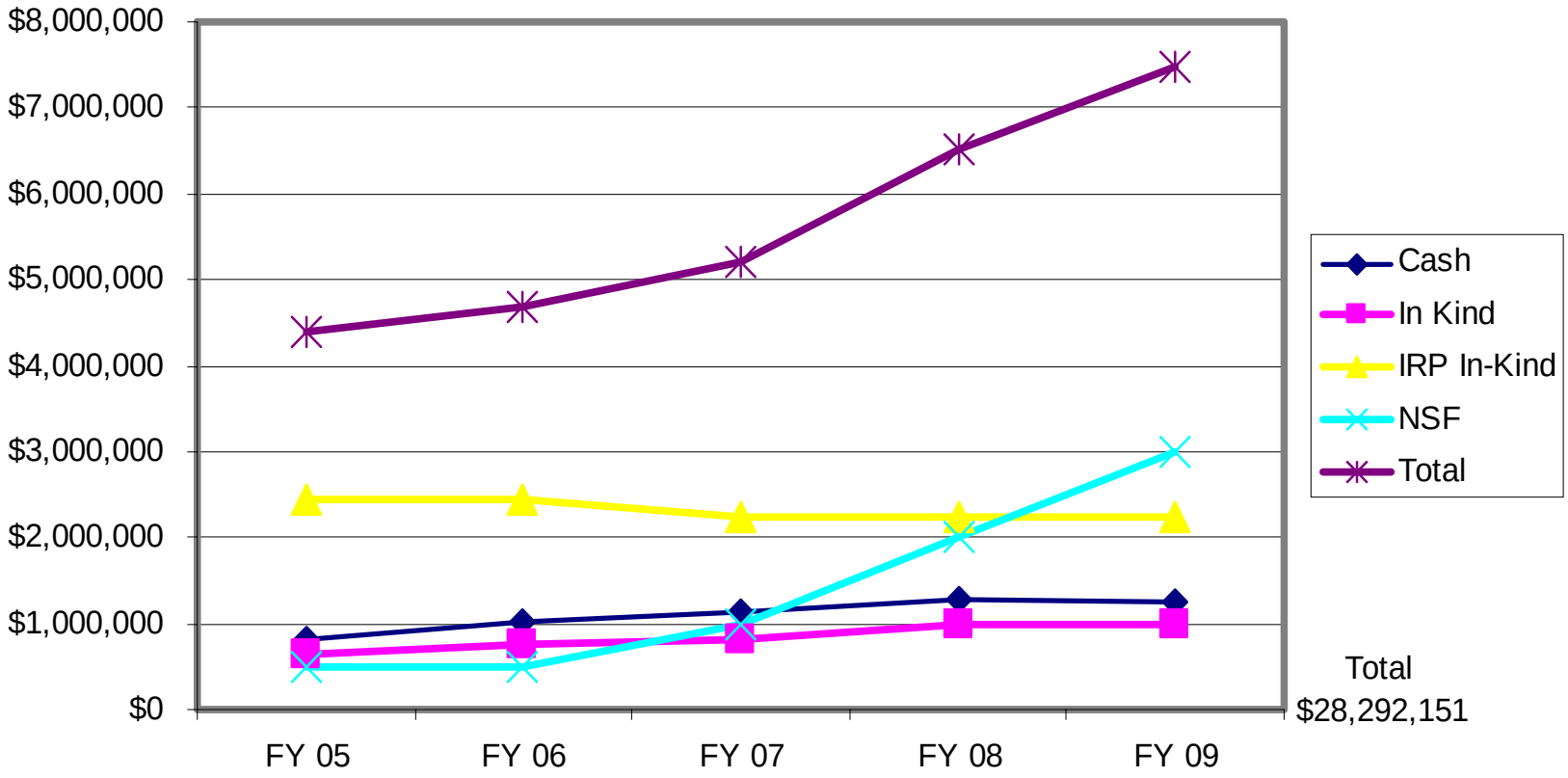
Committed

We have found in our partners tremendous enthusiasm to participate in the proposed open research platform, which is unconstrained by any agency mandate.

*Thus far, in addition to anticipatory contributions, the NCHS has secured firm support of **$18 Million** from our partners.*



Budget

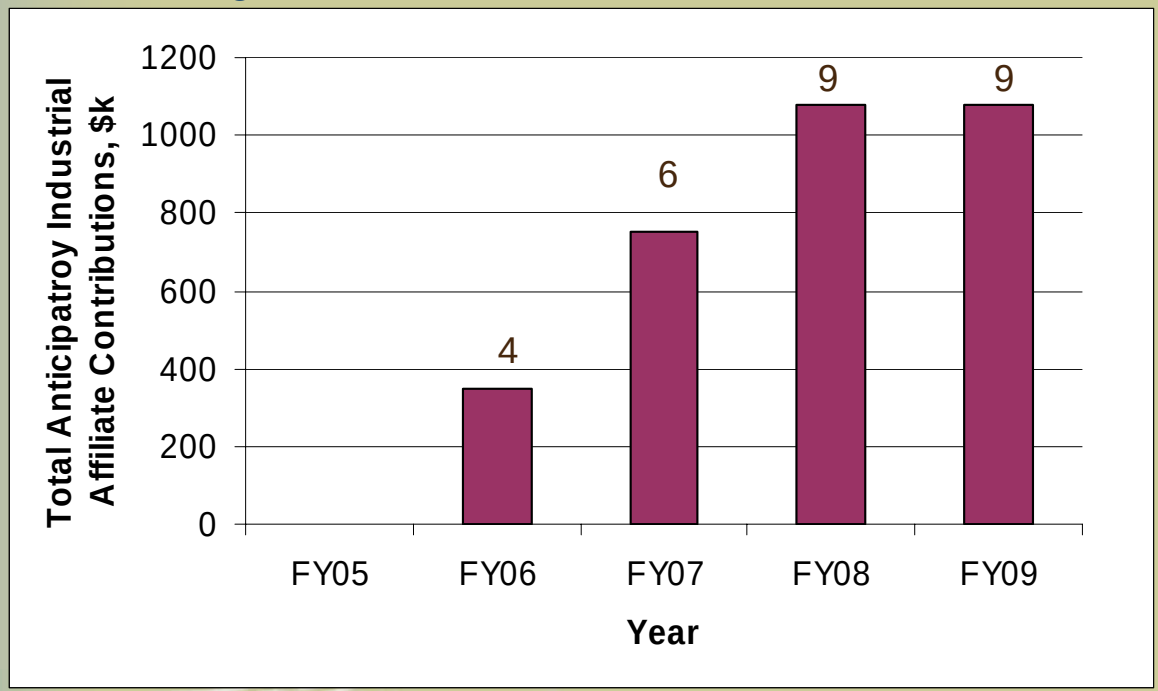


Yearly Budget: ~$4.3 to 7.4 Million

Five Year NCHS Budget: $ 28 Million

Budget includes Anticipatory Industrial Affiliate Contributions

- Total of $3.26m over 5 years;
- This is a *Conservative* Estimate:
  - It represents only 20% of what has already been raised overall ($18m) at this early proposal stage;
  - NCHS already has 4 Industrial affiliates: MP, LFR, Bechtel, Schlumberger



Budget includes expectation of 4-9 affiliates per year, with each IA contributing 65k - 125k per year.

- Is there a message in all this?
- Enthusiasm about the concept of “demilitarized”, mandate-free research environment;
- Support to the concept of community-based research
- A sense of urgency
- Trust in the Center’s ability to broker a mutually-beneficial, mutually respectful, and long term partnerships.

Looking Forward…Marketing the Center

- **Partnership program** enables the enrichment of the Center's intellectual environment, helps to extend the NCHS and CUAHSI activities internationally, and assists the center financially;

- **Naming opportunities** We will approach corporations, foundations and individuals with interest in the Center's scope of activity. Examples of naming opportunities include:
  - Named fellowships;
  - Named computational center
  - Named residencies (artist-in-residence, science writer-in-residence).
  - Named Conferences *(Example: Giannini Foundation $25k*)

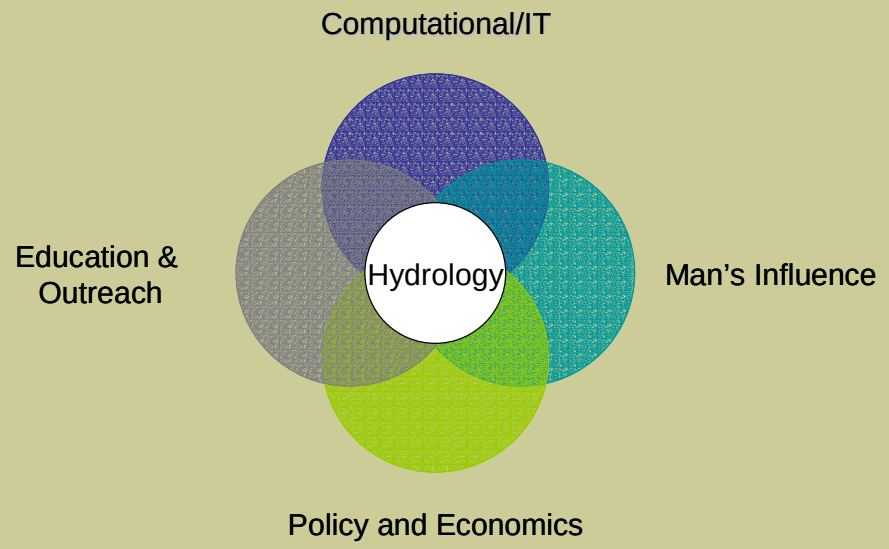
- **Research Contracts** -the Center will accept research grants that fit its mission, complement its activities, and provide long-term benefits for the Center and for the CUAHSI community (ex: UNESCO, the World Bank, and the CAL-FED Consortium).

- **Endowments and Capital Campaign**

Our success at this <u>early proposal stage</u> suggests that we should be able to successfully market the center

Seeds of Synthesis

- WG on Observatories (George Hornberger, U. Virginia);
- WG on Advanced Instrumentation (Jeff McDonell, U. Oregon);
- Hydrologically compatible Institutions (Henry Vaux, UCB);
- Computational Hydrology Assimilation and Infrastructure;
- Hydrology Education and Outreach



Computational Hydrology and Assimilation Infrastructure (CHAI)

- Central to the NCHS's success is the ability to perform computationally intensive high resolution, large domain distributed hydrologic simulations and to share the resulting output data, visualization, and analysis with other CUAHSI affiliates and partners, HIS, and ultimately policy makers and stakeholders.

- The Core CHAI WG members include Norm Miller (Hydrometerologist, LBNL), Deb Agarwal (Collaborative Lead and Distributed Systems Dept. Head, NERSC LBNL), Paul Houser (Head, Hydrological Sciences Branch NASA), Chaitan Baru (Director of Science R&D and SDSC-CAL-IT^2 PI, San Diego Super Computer), Bill Johnston (LBNL NERSC grid expert), and Toby Lehman (IBM Almaden Project Leader: Optimal Grid and T-Spaces).

How to measure success? How to learn from failures?

- Questions to address include: Is the work being done of the highest caliber? Is the research of individual researchers or groups taking advantage of the uniqueness of the Center? Is it interdisciplinary?
- In order to address these and other questions, metrics need to established, based on the level of (or potential for) scientific discovery or innovation, trends in institutional funding, enhancing the richness of the undergraduate or graduate experience, institutional reputation, ability to attract increasing numbers of outstanding researchers, societal relevance of problems being addressed.
- These questions need to be addressed through performance metrics, through surveys, and through internal and external review committees.

Specific Metrics:

- **IRA Specific**: When an IRA is established, it will be associated with milestones and will be evaluated by its ability to reach its milestones;
- **Scientific metrics**: rate and caliber of publications, diversity of authorship and publication outlets, citations, our ability to attract first-rate scientists and scholars, job placement of our graduates;
- **Public outreach metrics**: hits on our web site, participation in activities, number and caliber of students participating in our programs, our ability to draw funding for development;
- **Industry metrics**: recruitment and retention of affiliates, rate and quality of technology transfer: adoption of new technology, patents, participation of visiting scholars;
- **General membership metrics**: diversity and caliber of participation, polling the memberships, satisfaction questionnaires;

Summary

- The National Center for Hydrologic Synthesis will be established in Berkeley;
- Expected to commence operations in October, 2005
- We look forward for a very fruitful cooperation with our Partners from Finland!!